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(54) Title: MOLDED ELECTRONIC ASSEMBLY

(57) Abstract: A molded electronic assembly is formed from a first molded plastic portion including a component mounting plane and a plurality of non-coplanar surfaces, and a second molded plastic portion molded around the first molded plastic portion and including openings therein defining selected regions of the first molded plastic portion. Metallization is applied to the selected regions of the first molded plastic portion defining a network of electrically conductive traces and conductive regions providing electrical continuity over at least two of the non-coplanar surfaces. A battery is supported above the component mounting plane by stand-offs formed in the second molded plastic portion, and a circuit protection device is mounted in substantial contact with the battery. A method for assembling an electronic module is also described.

MOLDED ELECTRONIC ASSEMBLY

FIELD OF THE INVENTION

This invention relates generally to electronic circuit modules and in particular to electronic circuit modules constructed in plastic housings, and is more particularly directed toward a molded electronic assembly including a battery, electronic circuit protection, electronic components, and an external connector, combined in an integrated assembly.

BACKGROUND OF THE INVENTION

A key feature of products such as cellular mobile telephones is that they are "wireless," i.e., there is no cable for connection to a power source or to a communications line. Power is obtained from rechargeable batteries (battery packs) and radio waves are used as the communications medium. Another, not so obvious, feature of these products is that the product housing itself is often an integral part of the user interface, providing appropriate support and accessibility for keypads, displays, memory modules, battery packs, and connectors.

The key characteristics of highly portable consumer products generally are small size and weight, many

attractive features and capabilities, low cost, and short product life cycles. These characteristics are driven in part by the portable, hand-held nature of the products themselves, by the intense competition attributable to the size and growth rate of the respective markets, and by constantly improving technology in terms of design tools and integration.

Suppliers to manufacturers in volatile markets must ensure that they provide benefits compatible with the characteristics, motivations, and trends in the applicable market. Typically, these benefits should include size and weight reduction, feature expansion, enhanced levels of integration, lower cost, and shorter design cycles.

Size reduction is limited by components such as the battery pack, but it is also aided by technologies such as integrated circuit designs yielding higher performance devices with lower power consumption. Reductions in power consumption of portable products have, in turn, permitted a reduction in the electrical capacity of batteries used to power these units. Since the units themselves require less current, the capacity of the associated battery to deliver current to a load (measured, for example, in milliampere-hours) may also be reduced, resulting in the specification of batteries that are physically smaller. Advances in battery cell chemistry (i.e., lithium ion and polymer lithium ion) have resulted in reduced battery size as well.

Improvements have been observed in the art insofar as IC size reduction and integration and battery size reduction are concerned, but not all technologies have developed along similar lines. Housings, interconnections, assembly features, component platforms, and connectors have not become significantly smaller, nor have they benefited from improved integration techniques in terms of parts count or ease of assembly. Thus, the battery pack area provides a significant new opportunity in electronic and

electromechanical design and manufacture. Portable product battery packs comprise an array of components such as batteries and battery terminations, that must be connected to a circuit board that is in turn soldered to separate battery connectors, and then inserted into a plastic housing. The housing alone may comprise two or more plastic piece parts. A need therefore arises for an enhanced level of integration for electronic modules, particularly battery packs, that include a housing, electronic components, and connectors.

SUMMARY OF THE INVENTION

These needs and others are addressed by the molded electronic assembly of the present invention, in which electronic components, electronic circuit traces, connectors, and housing are integrated in one assembly. In an exemplary embodiment, the molded electronic assembly provides a housing, mounting details for an associated battery, a circuit protection device mounted in contact with the battery, and electrical connectors that provide proper connectivity between the molded electronic assembly and the mobile telephone in which it is installed. The basic package is applicable to many designs and configurations, and results in a reduced number of assembly steps in manufacture, lower cost, and further miniaturization for products in which it is utilized.

In one form of the invention, a molded electronic assembly comprises a first molded plastic portion including a component mounting plane and a plurality of non-coplanar surfaces, a second molded plastic portion molded around the first molded plastic portion and including openings therein defining selected regions of the first molded plastic portion, metallization applied to the selected regions of the first molded plastic portion defining a network of

electrically conductive traces and conductive regions providing electrical continuity over at least two of the non-coplanar surfaces, a battery supported above the component mounting plane by stand-offs formed in the second molded plastic portion, and a circuit protection device mounted in physical contact with the battery. One of the first and second molded plastic portions is formed from a platable plastic material. Preferably, the first molded plastic portion is formed from a glass-filled high temperature thermoplastic loaded with conductive filler material. The second molded plastic portion is preferably formed from a glass-filled high temperature thermoplastic.

In accordance with one aspect of the invention, the metallization is a multiple step plating process including both electroless and electrolytic plating operations. A pre-treatment process including cleaning, swelling, and etching operations may be applied prior to the first electroless plating operation.

In one embodiment of the invention, the battery is electrically connected to the molded electronic assembly via battery connection tabs formed in the platable plastic portion and including conductive regions metallized thereon. Preferably, electrical connection to the battery is established by welding.

In another embodiment of the invention, the circuit protection device is mounted in substantial contact with the battery by disposing the circuit protection device onto a mounting plane formed from both the first and second molded plastic portions. Electrical connection to the circuit protection device may also be established by welding.

In still another embodiment of the invention, a plurality of electronic components are placed onto conductive pads formed in the component mounting plane, and

electrical connection to the electronic components is established by reflow soldering.

Preferably, the circuit protection device is a polymer positive temperature coefficient device having a relatively low resistance at a normal operating temperature and whose resistance increases relatively steeply at a device switching temperature. The resistance of the circuit protection device returns to a relatively low resistance as temperature falls below the device switching temperature.

In accordance with yet another embodiment of the invention, an electronic assembly comprises a plastic housing having a base portion and at least one integrally formed sidewall portion, wherein adjacent interior surfaces thereof define an interior volume of the plastic housing, a first pattern of electrically conductive material disposed upon the adjacent interior surfaces, a plurality of electronic components disposed upon at least one of the interior surfaces and electrically connected to the first pattern of electrically conductive material, and a second pattern of electrically conductive material disposed upon at least one exterior surface of the plastic housing, wherein the second pattern of electrically conductive material is electrically connected to the first pattern of electrically conductive material. In one form of this embodiment, the second pattern of electrically conductive material forms an electrical connector. The electrical connector preferably includes non-coplanar conductive portions.

In another form of this embodiment, a battery is electrically connected to the first pattern of electrically conductive material. The battery is preferably supported adjacent the electronic components disposed upon the interior surfaces, and the battery is housed substantially within the interior volume of the plastic housing.

In still another embodiment of the invention, an antenna is formed in the first pattern of electrically conductive material. The antenna may be a planar antenna.

In yet a further embodiment of the invention, a method for assembling an electronic module comprises the steps of forming a plastic housing in a two-shot molding process in which a second plastic material at least partly surrounds a first plastic material, applying metallization to selected areas of the housing to define electrical circuit traces and component mounting areas, disposing electronic components in the component mounting areas, establishing electrical connections with the electronic components through a reflow solder process, and disposing and electrically connecting at least one further component in a post-reflow attachment process.

The step of forming a plastic housing further comprises the steps of injecting a first plastic material into a mold to form a first-shot molded assembly, placing the first-shot molded assembly into a second mold, and injecting a second plastic material into the second mold to form the plastic housing.

The first plastic material may be a platable plastic material, while the second plastic material may be a non-platable plastic material. Preferably, the step of applying metallization to selected areas further comprises the steps of applying a sequence of conductive layers through both electroless and electrolytic deposition, wherein the selected areas of the housing comprise areas where the first plastic material is accessible through openings in the second plastic material. In accordance with one embodiment of the invention, the sequence of conductive layers is applied to form at least one electrical connector on a surface of the plastic housing that is non-coplanar with at least one of the component mounting areas.

Preferably, the step of disposing electronic components in the component mounting areas further comprises disposing electronic components through a pick-and-place process that positions the electronic components on component mounting pads formed during metallization. Adhesive may be applied to appropriate mounting areas prior to the pick-and-place process to secure the electronic components in position prior to reflow soldering.

In accordance with still another embodiment of the invention, the step of disposing and electrically connecting at least one further component in a post-reflow attachment process further comprises the steps of preparing the at least one further component for the attachment process by securing electrical contacts to the component, placing the at least one further component in position on the plastic housing, and electrically connecting the at least one further component's electrical contacts to selected component mounting areas by a welding process. The further component attached in the post-reflow process may be a battery.

Further objects, features, and advantages of the present invention will become apparent from the following description and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cut-away perspective view of a molded electronic assembly in accordance with the present invention;

FIG. 2 is a section view along section lines 2-2 of FIG. 1;

FIG. 3 is a perspective view of a simplified form of a substrate used in the invention, illustrating a pattern of conductive circuit traces formed on the substrate;

FIG. 4 is a section view along section lines 4-4 of FIG. 3;

FIG. 5 is a perspective view of the first-shot molded portion of the electronic assembly of FIG. 1;

FIG. 6 is a perspective view depicted features added to the view of FIG. 5 by the second-shot molding process;

FIG. 7 is a section view along section lines 7-7 of FIG. 6;

FIG. 8 is a perspective view of the molded electronic assembly of FIG. 1;

FIG. 9 illustrates connector and mounting tab details of the molded electronic assembly of FIG. 1;

FIG. 10 is a partially cut-away perspective view showing alternative positioning of battery tabs, and indicating placement of a circuit protection device;

FIG. 11 is a side elevational view of the molded electronic assembly of FIG. 10;

FIG. 12 is a perspective view of an alternative embodiment of a molded electronic assembly in accordance with the present invention;

FIG. 13 is a schematic diagram illustrated the application of a circuit protection device;

FIG. 14 is a simplified block diagram example of electronic circuit protection;

FIG. 15 is a perspective view of yet another alternative embodiment of a molded electronic assembly in accordance with the present invention; and

FIG. 16 is a flow chart depicted process steps involved in producing the molded electronic assembly of FIG. 1.

DETAILED DESCRIPTION OF THE INVENTION

In accordance with the present invention, a molded electronic assembly is described that offers distinct

advantages when compared with the prior art. FIG. 1 is a perspective view of a molded electronic assembly in accordance with the present invention, generally depicted by the numeral 100, and partially cut away to illustrate electronic component location. The molded electronic assembly 100 is formed utilizing a two-shot molding process that permits injection molding of an integrated assembly from two plastics with similar molding properties that nonetheless differ in some respects. This fabrication process will be described in greater detail subsequently.

A prominent feature of the assembly 100 is the battery 101, which is both mechanically supported and electrically connected through integrally formed features of the assembly 100, such as locator tab 102 and support stand-offs 201 (FIG. 2). Electrical connections are made to the battery 101 through metallic battery connector strips 105, which are preferably welded both to contacts on the battery 101 and to battery connector tabs 103. The welding process will be discussed in more detail below.

The battery connector tabs 103 are formed during the two-shot molding process, and are metallized so that there is an electrically conductive path from each tab 103 to an appropriate portion of the electrical circuit paths or traces 106 and component mounting pads 110 that are formed on the substrate 104 during the manufacturing process.

The battery connector tabs 103 and battery locator tab 102 are integrally formed sidewall portions of the complete plastic housing of the molded electronic assembly 100. The interior surfaces 203, 204 of these sidewall portions 102, 103, in conjunction with the substrate surface 104 to which they are adjacent, define an interior volume of the assembly 100. This is particularly evident in FIG. 2 where a dashed line 202 connects end points A, B of the sidewall portions 203, 204. The battery 101 is substantially contained within the interior volume thus defined. In

fact, the overall thickness of the completed molded electronic assembly 100, measured from a housing exterior surface 205 to the plane 202 defined by the end points A, B of the sidewalls, is preferably no more than about twice the thickness of the battery 100 itself. In the illustrative embodiment, the molded electronic assembly 100 does not have a cover, but it could be provided with a cover portion approximately coextensive with the dashed line 202 of FIG. 2.

FIGS. 3 and 4 are illustrative of the manner in which a substrate incorporating electrically conductive circuit traces is fashioned using two-shot molding. FIG. 3 shows a substrate 301 with a pattern of electrically conductive circuit traces 302 disposed thereupon. The section view of FIG. 4 shows more clearly that the substrate 301 of FIG. 3 is actually a composite of a first shot-molded substrate portion 401, a second-shot molded portion 402 that partially encapsulates or surrounds the first-shot molded substrate portion 401, and a metallization process that produces the electrical circuit traces 302.

Both the first-shot and second-shot molded portions 401, 402 are formed from a high temperature thermoplastic that is suitable for electronic applications. Preferably, these plastic materials are liquid crystal polymers (LCPs), although there are other types of high temperature plastics that would also be suitable in this application.. The LCP used for the first-shot molding process is preferably loaded with metal filler particles, such as palladium, in order to make the first-shot molded portion platable. The plastic material used for the second-shot molded portion does not have such a metallic filler in order to make the second-shot molded portion 402 inert to pre-treatment and plating chemistry for reasons that will be explained below.

The plastic materials selected for both the first and second shot molding operations should have a high heat

deflection temperature (HDT) in order to make the molded plastic part suitable for reflow soldering operations. Preferably, both the first and second shot plastic materials are reinforced with non-metallic fibers, such as glass, in order to enhance their mechanical properties and reduce the undesirable effects of the anisotropy of LCPs. A suitable quantity of fiber fill by percentage is in the range of from 20 percent to 40 percent.

During the manufacturing process, the first-shot plastic material is injection molded to form the first-shot molded substrate portion 401. Then, this first-shot molded substrate portion is placed into a second mold for which it forms a portion of the mold volume. The second-shot mold is designed to place the second-shot molded plastic material 402 as shown in FIG. 4, so that it effectively acts as a mask for the formation of the conductive traces 302. Of course, it is technically possible to reverse the order in which the materials are molded, i.e., make the first-shot molded plastic the non-platable plastic and the second-shot molded plastic the platable plastic. This type of process variation would be largely dictated by the specific application.

In preparing the exposed surfaces of the first-shot molded material to accept metallization, a series of cleaning, swelling and etching steps are applied, such as would be known to one of ordinary skill in the art, in order to sufficiently activate the surface of the platable plastic material without adversely affecting the surface of the non-platable plastic. The surface of the non-platable plastic material remains inert and hydrophobic.

The plating process that results in the formation of the conductive traces 302 is a combination of electroless and electrolytic processes. First, electroless copper is deposited on the prepared areas of the first-shot molded plastic to a thickness in the range of 2 to 4 microns, then

a layer of copper is deposited in an electrolytic process over the electroless layer to a thickness of 30 to 40 microns.

A layer of nickel having a thickness ranging from 2 to 6 microns is then deposited over the copper using an electroless process, primarily as a diffusion barrier, but also because of its hardness and resistance to wear. A very thin immersion layer of gold, having a thickness of 0.1 to 0.25 microns, is then applied to ensure a low contact resistance, especially for connector applications.

FIG. 5 depicts the portion 500 of the molded electronic assembly 100 that is formed in the first-shot mold. Holes 108 where vias (plated-through holes) will be provided are also shown. The vias 108 will provide conductive paths from one side of the substrate 104 to the other side. In this case, the vias 108 provide electrically conductive paths to electrical connectors 109 on the opposite side of the substrate 104. The component mounting pads 110 are also indicated in FIG. 5.

As mentioned previously, the plastic materials selected for construction of the molded electronic assembly 100 are compatible with a reflow soldering process. In populating the component mounting area of the substrate 104, conventional pick-and-place technology is used to locate electronic components 107, such as surface-mount integrated circuit packages and chip components such as resistors and capacitors. As is known in the art, solder is deposited on component mounting pads prior to the placing of electronic components 107, and the components themselves are often held in their proper positions through the use of an adhesive deposited prior to component placement. The entire assembly is then guided through a reflow oven that heats the solder to its melting temperature, thus making proper electrical connection to the electronic components 107.

Some electrical and electronic components should not be exposed to a reflow oven, however. In the production of the molded electronic assembly 100 of the present invention, the battery 100 is not subjected to a reflow process. Instead, the battery connector strips 105 are connected to the battery 101 by welding, and the connector strips 105 are connected to the battery tabs 103 by a welding operation that takes place after reflow.

The welding operation can be ultrasonic, which minimizes heat stress for the components being connected while producing a serviceable electrical connection between the metals being welded. Of course, the welding process could also be thermal, since the localized and time-limited exposure of proper thermal welding also subjects sensitive components to less thermal stress than reflow. There are even soldering processes that can be performed post-reflow, with proper fixturing, that can be suitable for sensitive components.

It should be noted that the electrical connectors 109 formed in the preferred embodiment are constructed without any metallic mold inserts, which is a preferred method of connector construction in the prior art. The electrical connectors 109 of the present invention have been demonstrated to satisfy electromechanical requirements for electrical contacts without the need for inserting contact elements into the mold and molding plastic around them.

In fact, the electrical connectors 109 of the present invention include three-dimensional features in the form of extended conductive portions 901 that extend beyond the edge 902 of the assembly 100, and beyond the plane in which the remainder of the conductive surface of the connector 109 lies. Since the extended portions 901 of the connectors 109 are formed from platable plastic material, these extended portions 901 can be plated over all of their surface area. This ensures that the connectors 109 are in

proper mechanical and electrical engagement with mating contact portions. This three-dimensional feature provided by the extended portions 901 of the connectors 109 means that the molded electronic assembly 100 of the present invention satisfies the definition of a 3-D MID, or three-dimensional molded interconnect device.

FIG. 6 illustrates the portions of the molded electronic assembly 100 that are formed during the second-shot molding process. After the first-shot molding process is completed, the first-shot molded plastic portion 500 is placed into a second mold where the first-shot molded portion 500 forms a part of the mold volume. This process has been described above with reference to FIGS. 3 and 4.

The mold is sealed and a second plastic material is injected. This second plastic material is a non-platable plastic that is used to form areas of the completed molded assembly 100 that do not require metallization. As discussed above, the second non-platable material acts as a mask that is cut out appropriately (by virtue of the mold details) to prevent the subsequent metallization process from affecting areas of the completed product on which no metallization is desired.

Of course, for two-shot molding processes involving relatively thin materials and low-profile structural details, it is often necessary to provide surface details in the first-shot mold to ensure adequate material flow in the second-shot process. This can be accomplished through the addition of flow channels formed in the surface of the first-shot molded materials, and through-holes in strategic locations to ensure that the second-shot mold fills properly. Of course, the exact arrangement of such fill channels and holes is largely dictated by the specific plastics used, the location of injection points in the second-shot mold, and the geometry of the finished product. For relatively thin products, on the order of 1 mm, a

pattern of fill channels and holes will probably be required to ensure a proper fill of the second-shot material.

Through care in the production of the molds used in the two-shot molding process, fairly small geometries may be attainable. The molded electronic assembly 100 of the present invention has been constructed with electrical circuit paths or traces 106 as narrow as 250 microns, with spacing between adjacent electrical circuit paths 106 also held to as small as 250 microns.

Structural details of the completed product are also formed in the second-shot mold, as indicated in FIG. 6. Examples of these areas include the battery locator tab 102 and the support stand-offs 201 that support the battery 101 above the electronic components 107 installed on the substrate 104 (see FIG. 1). As will be clear from FIG. 6, the plastic material deposited during the second shot molding process is formed on, and at least partially surrounds, the plastic material 500 of the first shot molding process.

FIG. 7 is a section view of the second-shot molded assembly of FIG. 6, and helps in identifying the portions of the assembly that are formed in each molding step. A first portion 701 is formed during the first-shot molding process, and typically form interior sections of the finished part, or protruding portions that require metallization, such as the battery tabs. A second portion 702 that is formed during the second-shot molding process tends to encapsulate or surround the portion 701, in order to provide a proper mask for subsequent metallization. Structural details of the finished product, such as the stand-offs 201 for the battery and the battery locator tab 102 (FIG. 8) are formed from the second portion 702.

FIG. 9 depicts connector and mounting tab details of the molded electronic assembly 100, as shown from the

reverse side. The vias 108 (FIG. 5) that provide electrical connectivity from the conductive pattern 106 of the substrate 104 to the external connectors 109 have been plated through during the metallization process as described above with reference to FIGS. 3 and 4. In the same metallization process, conductive regions are established on the battery connection tabs 103, and appropriate electrical connections are established to the network of conductive traces 106 on the component mounting surface 401.

Conductive pathways are integrally fabricated to provide electrical connections between non-coplanar surfaces such as the battery tabs 103 and the conductive traces 106. This electrical connectivity can be established both with and without the use of vias 108, as illustrated. The non-platable plastic portion 702 of the second shot molding process also serves to provide electrical insulation where desired, such as between the connector contacts 109, in addition to providing structural features.

The perspective view of FIG. 10 illustrates an alternative arrangement for battery tabs 1002 to accommodate a battery 1001 having its connections positioned so as to be more easily accessed by metal battery connector strips 1003 that terminate on the battery tabs 1002 positioned on opposite sides of the battery 1001. The cut-away also shows a circuit protection device 1004 that is positioned in proximity to the battery 1001 (as illustrated in FIG. 11). Preferably, the circuit protection device 1004 is in direct physical contact with the battery 1001, but if the device is within about 0.1 mm of the battery, it will still function correctly. Of course, if the circuit protection device were a conventional fuse rather than a temperature-responsive

device, proximity to the battery would not be a requirement.

The circuit protection device 1004 is therefore mounted close enough to the battery 1001 so as to be responsive to battery temperature. A mounting stand-off 1102 is formed as a result of the two-shot molding process in order to ensure that the circuit protection device 1004 is positioned properly with respect to the battery 1001. The circuit protection device 1004 will be discussed in more detail subsequently. In order to minimize the possibility of damage to the circuit protection device 1004 caused by exposure to the high temperatures of a solder reflow process, the circuit protection device 1004 is preferably welded in position after the reflow operation that is used for the majority of electronic components in the molded electronic assembly 100.

FIG. 12 illustrates an alternative embodiment of the molded electronic assembly, generally depicted by the numeral 1200, that features external connector contacts 1201 disposed in a plane at right angles to a substrate portion 1203 on which conductive electrical circuit traces 1202 and electronic component soldering pads 1204 are disposed. Consequently, the alternative assembly 1200 is fabricated in an L-shape. Electrical contact traces 1202, 1205 provide electrical connectivity over at least two non-coplanar surfaces in this embodiment as well.

The circuit protection device 1004 described in conjunction with FIGS. 10 and 11 is preferably a polymer positive temperature coefficient (PTC) device made from a conductive polymer blend of plastic and conductive particles. Such devices are well-known in the art. See, for example, U.S. Patent No. 6,020,808 issued to Hogge. Of course, other types of devices that display a rapid change in resistance at a critical temperature may also be suitable.

As noted previously, the polymer PTC device is mounted very close to, or in contact with the battery, and the device resistance becomes very high in response to heating above its switching temperature. This heating can take place due to an increase in either ambient temperature or battery temperature, or it can be caused by resistive heating in the event of an overcurrent condition. This increased resistance reduces to a minimal level the amount of current that can flow under the fault condition and protects the battery and the equipment in the circuit.

FIG. 13 illustrates a voltage source 1301, which may be a battery, providing current I 1303 to a load R_L 1302. With the protection device 1004 positioned in contact with the battery, the device 1004 will respond quickly to an increase in temperature beyond its device switching temperature. As device resistance increases, current 1303 provided to the load 1302 is sharply reduced, thus protecting the voltage source 1301 and the load 1302. The polymer PTC device 1004 can be thought of as a resettable fuse, since its resistance will return to its normal low level once the device temperature falls below the device switching temperature.

The electronic circuit protection provided by the electronic assembly in accordance with the present invention extends beyond the circuit protection device described above. The electronic components 107 (FIG. 1) disposed on the conductive traces 106 can provide additional protection for a lithium ion or polymer lithium ion battery as illustrated in the simplified block diagram of FIG. 14.

A safety IC 1401, such as the SAA1504T device manufactured by Philips Semiconductors, controls the maximum normal charge and discharge levels for the battery, as well as providing a secondary protection level for overcharge and overdischarge conditions. A dual MOSFET

package 1402 is configured to interrupt the charge and discharge paths under control of the safety IC 1401. The safety IC 1401 constantly monitors the terminal voltage of the battery 101 and compares the measured value with an accurate internal reference voltage. As shown in FIG. 14, the electronic circuit protection provided includes a circuit protection device 1004, which provides a quick response to faults signaled by elevated battery temperature as described previously.

FIG. 15 is a perspective view of yet another embodiment of a molded electronic assembly, as generally depicted by the numeral 1500. The illustrated embodiment features external connector contacts 1501 that are disposed in a plane at right angles to a substrate portion 1503 on which conductive electrical circuit traces 1502 and electronic component mounting pads 1504 are disposed. Electrical contact traces 1502, 1505 provide electrical connectivity over at least two non-coplanar surfaces. In addition, the embodiment of FIG. 15 illustrates an antenna 1506 of a helical design implemented in the layout of the conductive circuit traces. Such an antenna 1506 would be a useful feature for an electronic assembly designed for inclusion in a communication unit, such as a mobile cellular telephone. Of course, other antenna geometries, such as various patch type antennas, could also be implemented. The antenna could be designed to extend over more than one non-coplanar surface in order to achieve a desired radiation pattern, or the antenna could be planar as illustrated.

FIG. 16 is a flow chart illustrating process steps involved in producing a molded electronic assembly in accordance with the present invention. As described above, a plastic housing is first formed (step 1601) in a two-shot molding process in which a first platable plastic material is at least partially surrounded or encapsulated by a

second, non-platable plastic material. Selective metallization is then applied in the next process step 1602 to provide electrically conductive circuit traces and electronic component mounting pads.

After metallization, electronic components are disposed on the plastic housing (step 1603) using pick-and-place techniques known in the art, in which an adhesive application step may also be used in order to hold the electronic components in their desired locations. The plastic housing with electronic components is then routed through a reflow oven in the next process step 1604.

Since it is possible that some components may be adversely affected by the reflow process, some components, such as a battery, for example, may be treated separately and attached to the assembly using other means (step 1605). In attaching a battery, one may elect to prepare the battery by attaching appropriate electrical contacts to the battery first, then placing the battery into its appropriate position within the plastic housing and electrically attaching the battery through a post-reflow process such as welding. As discussed above, one may also choose to attach other sensitive components, such as a circuit protection device, in a similar post-reflow process.

There has been described herein a molded electronic assembly that has distinct advantages over the prior art. It will be apparent to those skilled in the art that modifications may be made without departing from the spirit and scope of the invention. Accordingly, it is not intended that the invention be limited except as may be necessary in view of the appended claims.

What is claimed is:

1. A molded electronic assembly comprising:

a first molded plastic portion including a component mounting plane and a plurality of non-coplanar surfaces;

a second molded plastic portion molded around the first molded plastic portion and including openings therein defining selected regions of the first molded plastic portion;

metallization applied to the selected regions of the first molded plastic portion defining a network of electrically conductive traces and conductive regions providing electrical continuity over at least two of the non-coplanar surfaces;

a battery supported above the component mounting plane by stand-offs formed in the second molded plastic portion; and

a circuit protection device mounted in substantial contact with the battery.

2. The molded electronic assembly of claim 1, wherein one of the first and second molded plastic portions is formed from a platable plastic material.

3. The molded electronic assembly of claim 1, wherein the first molded plastic portion is formed from a glass-filled high temperature thermoplastic loaded with conductive filler material.

4. The molded electronic assembly of claim 1, wherein the second molded plastic portion is formed from a glass-filled high temperature thermoplastic.

5. The molded electronic assembly of claim 1, wherein the metallization is a multiple step plating

process including both electroless and electrolytic plating operations.

6. The molded electronic assembly of claim 5, wherein a pre-treatment process including cleaning, swelling, and etching operations is applied prior to the first electroless plating operation.

7. The molded electronic assembly of claim 1, wherein the battery is electrically connected to the molded electronic assembly via battery connection tabs formed in the platable plastic portion and including conductive regions metallized thereon.

8. The molded electronic assembly of claim 7, wherein electrical connection to the battery is established by welding.

9. The molded electronic assembly of claim 1, wherein the circuit protection device is mounted in physical contact with the battery by disposing the circuit protection device onto a mounting plane formed from both the first and second molded plastic portions.

10. The molded electronic assembly of claim 1, wherein electrical connection to the circuit protection device is established by welding.

11. The molded electronic assembly of claim 1, wherein a plurality of electronic components are placed onto conductive pads formed in the component mounting plane, and electrical connection to the electronic components is established by reflow soldering.

12. The molded electronic assembly of claim 1, wherein the circuit protection device is a polymer positive temperature coefficient device having a relatively low resistance at a normal operating temperature and whose resistance increases relatively steeply at a device switching temperature.

13. The molded electronic assembly of claim 12, wherein the resistance of the circuit protection device returns to a relatively low resistance as temperature falls below the device switching temperature.

14. An electronic assembly comprising:

a plastic housing having a base portion and at least one integrally formed sidewall portion wherein adjacent interior surfaces thereof define an interior volume of said plastic housing;

a first pattern of electrically conductive material disposed upon said adjacent interior surfaces;

a plurality of electronic components disposed upon at least one of said interior surfaces and electrically connected to said first pattern of electrically conductive material; and

a second pattern of electrically conductive material disposed upon at least one exterior surface of said plastic housing, wherein said second pattern of electrically conductive material is electrically connected to said first pattern of electrically conductive material.

15. The electronic assembly of claim 14, wherein said second pattern of electrically conductive material forms an electrical connector.

16. The electronic assembly of claim 15, wherein said electrical connector includes non-coplanar conductive portions.

17. The electronic assembly of claim 14, further comprising:

a battery electrically connected to said first pattern of electrically conductive material.

18. The electronic assembly of claim 17, wherein the battery is supported adjacent the electronic components disposed upon said interior surfaces, and said battery is housed substantially within said interior volume of said plastic housing.

19. The electronic assembly of claim 14, wherein an antenna is formed in the first pattern of electrically conductive material.

20. The electronic assembly of claim 14, wherein the antenna is a planar antenna.

21. A method for assembling an electronic module, the method comprising the steps of:

a) forming a plastic housing in a two-shot molding process in which a second plastic material at least partly surrounds a first plastic material;

b) applying metallization to selected areas of the housing to define electrical circuit traces and component mounting areas;

c) disposing electronic components in the component mounting areas;

d) establishing electrical connections with the electronic components through a reflow solder process; and

e) disposing and electrically connecting at least one further component in a post-reflow attachment process.

22. The method on accordance with claim 21, wherein the step (a) of forming a plastic housing further comprises the steps of:

a1) injecting a first plastic material into a mold to form a first-shot molded assembly;

a2) placing the first-shot molded assembly into a second mold; and

a3) injecting a second plastic material into the second mold to form the plastic housing.

23. The method in accordance with claim 22, wherein the first plastic material is a platable plastic material.

24. The method in accordance with claim 22, wherein the second plastic material is a non-platable plastic material.

25. The method in accordance with claim 21, wherein the step (b) of applying metallization to selected areas further comprises the steps of applying a sequence of conductive layers through both electroless and electrolytic deposition, and the selected areas of the housing comprise areas where the first plastic material is accessible through openings in the second plastic material.

26. The method in accordance with claim 25, wherein the sequence of conductive layers is applied to form at least one electrical connector on a surface of the plastic housing that is non-coplanar with at least one of the component mounting areas.

27. The method in accordance with claim 21, wherein the step (c) of disposing electronic components in the component mounting areas further comprises disposing electronic components through a pick-and-place process that positions the electronic components on component mounting pads formed during metallization.

28. The method in accordance with claim 27, wherein adhesive is applied to appropriate mounting areas prior to the pick-and-place process to secure the electronic components in position prior to reflow soldering.

29. The method in accordance with claim 21, wherein the step (e) of disposing and electrically connecting at least one further component in a post-reflow attachment process further comprises the steps of:

e1) preparing said at least one further component for the attachment process by securing electrical contacts to the component;

e2) placing said at least one further component in position on the plastic housing; and

e3) electrically connecting said at least one further component's electrical contacts to selected component mounting areas by a welding process.

30. The method in accordance with claim 29, wherein said at least one further component comprises a battery.

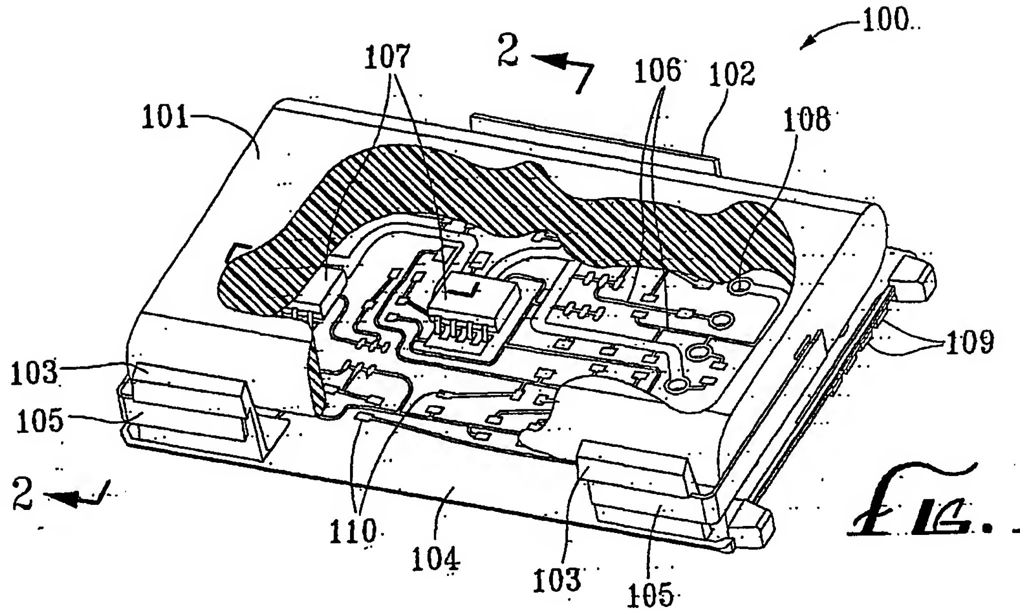
100
2
107
106
102
101
108
109
103
105
2
110
104
103
105

FIG. 1

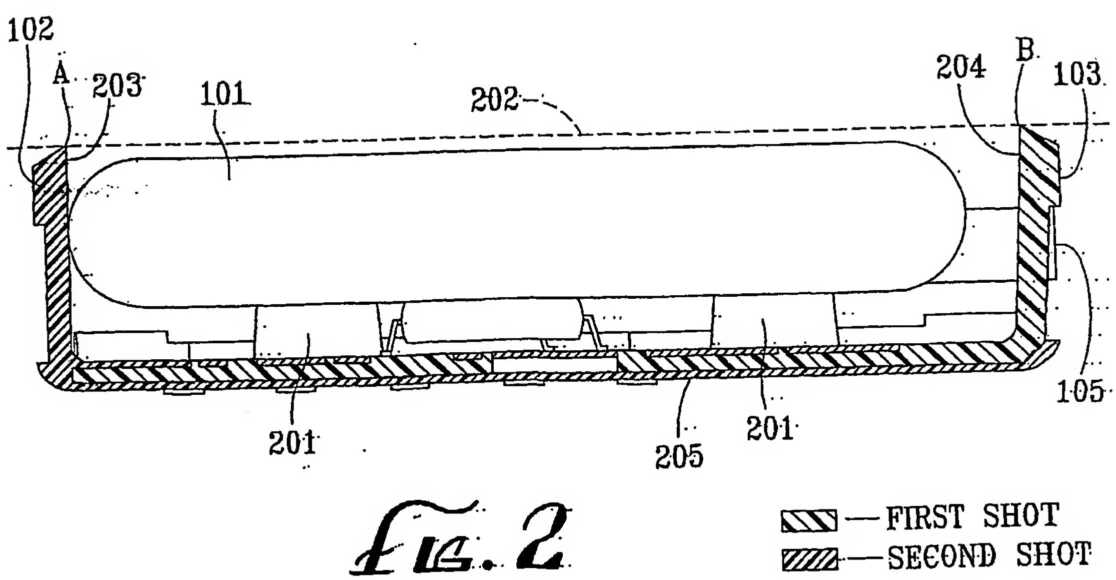
102
A
203
101
202
204
B
103
105
201
205
201
—FIRST SHOT
—SECOND SHOT

FIG. 2

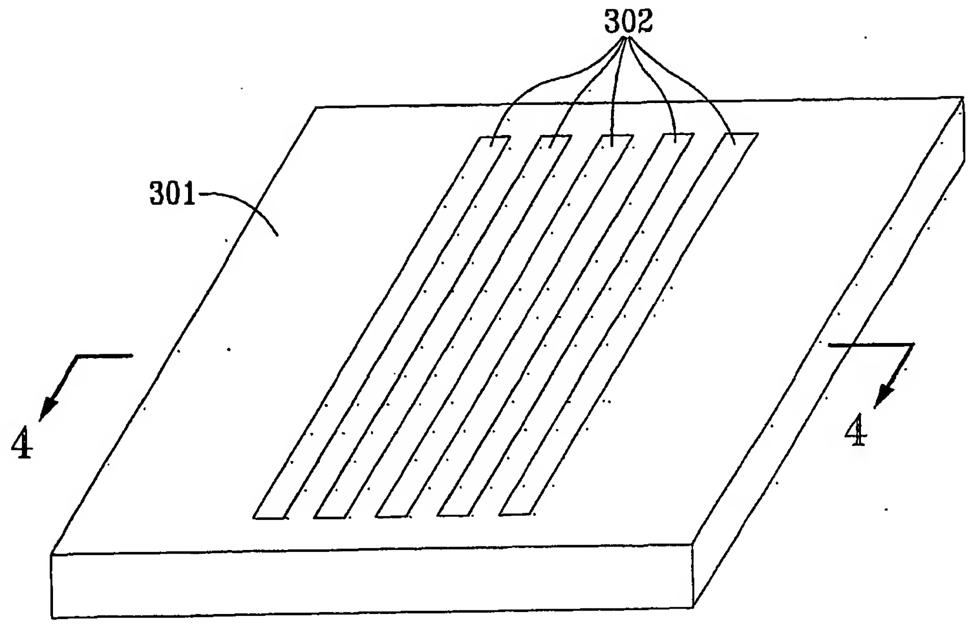

FIG. 3

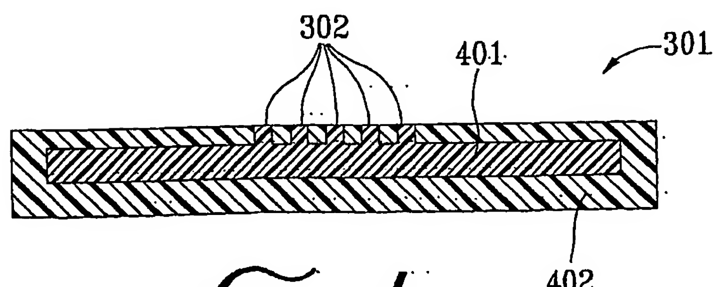

FIG. 4

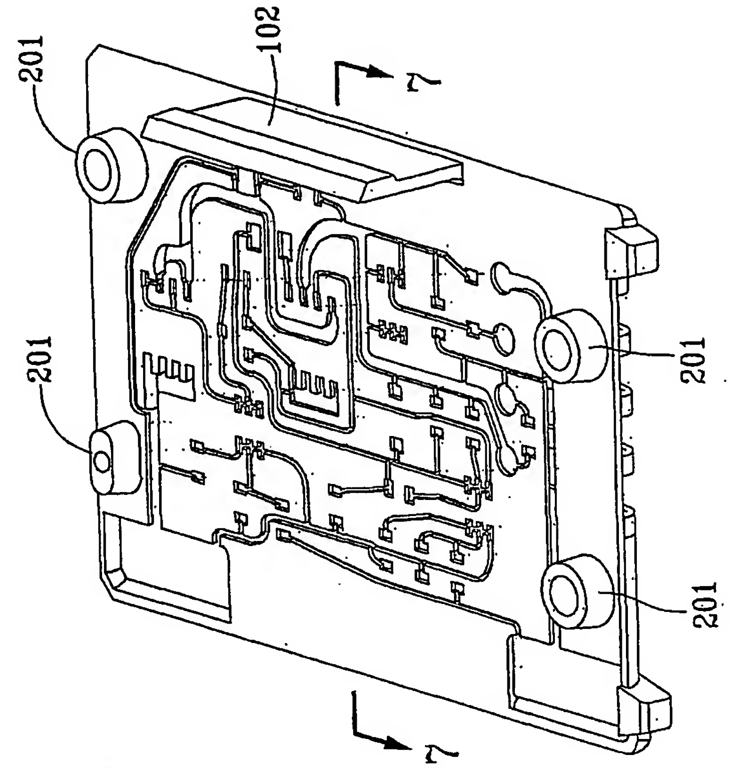

FIG. 6

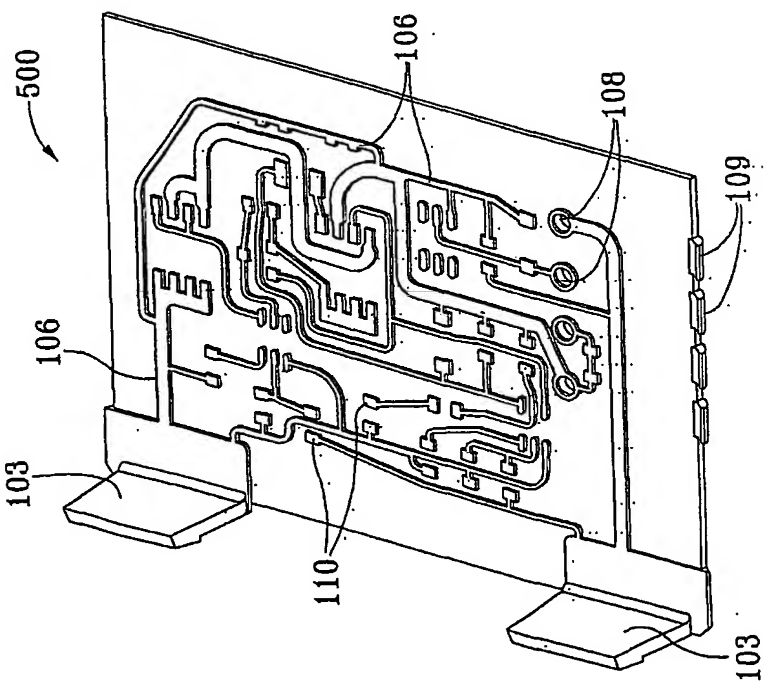

FIG. 5

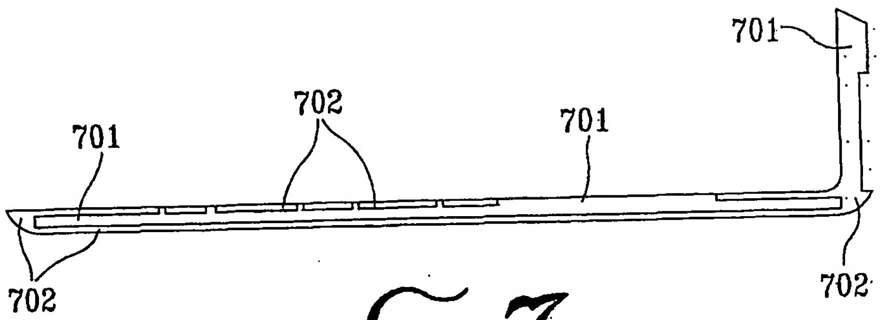

FIG. 7

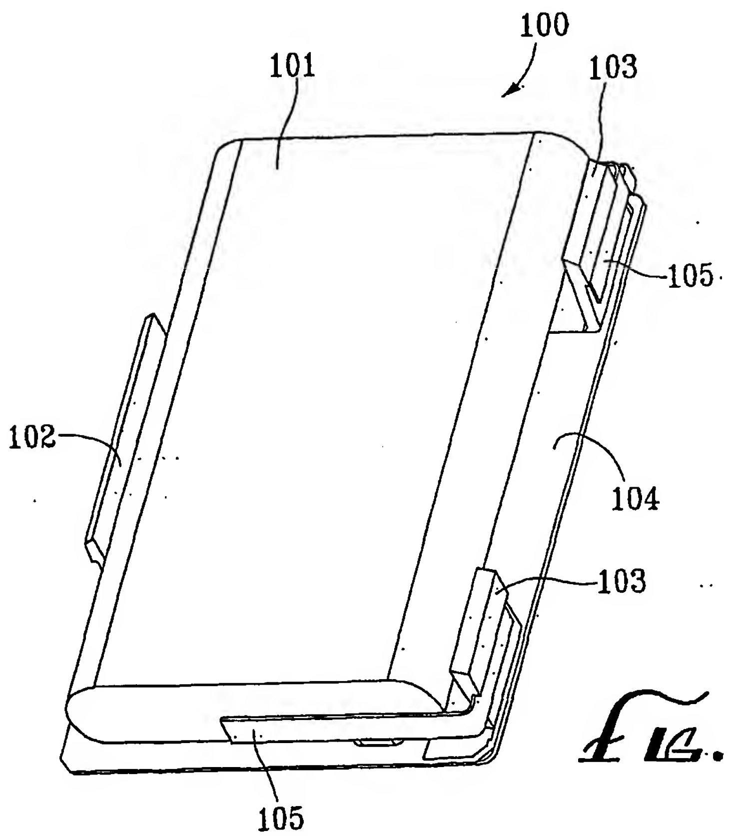

FIG. 8

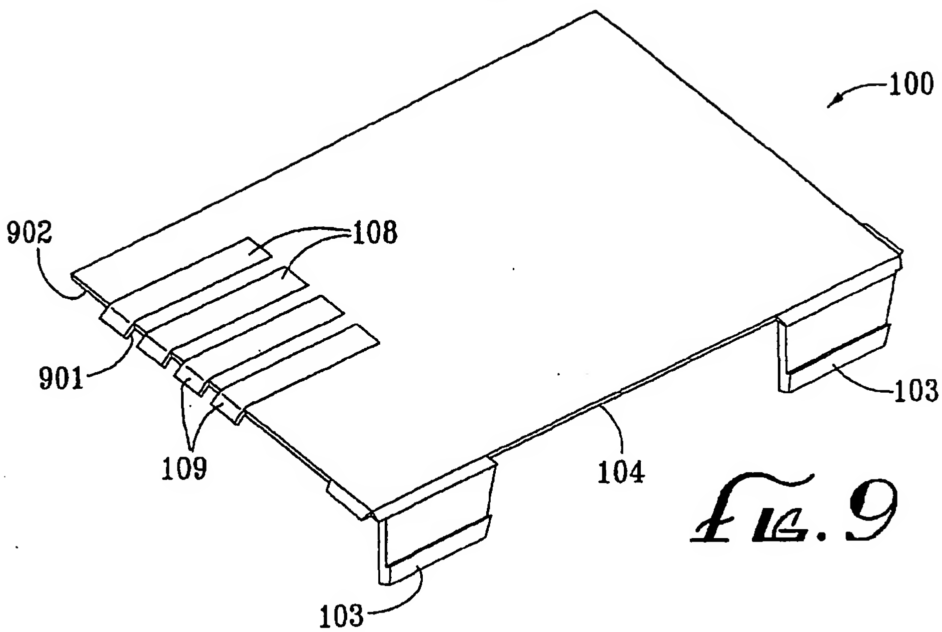

FIG. 9

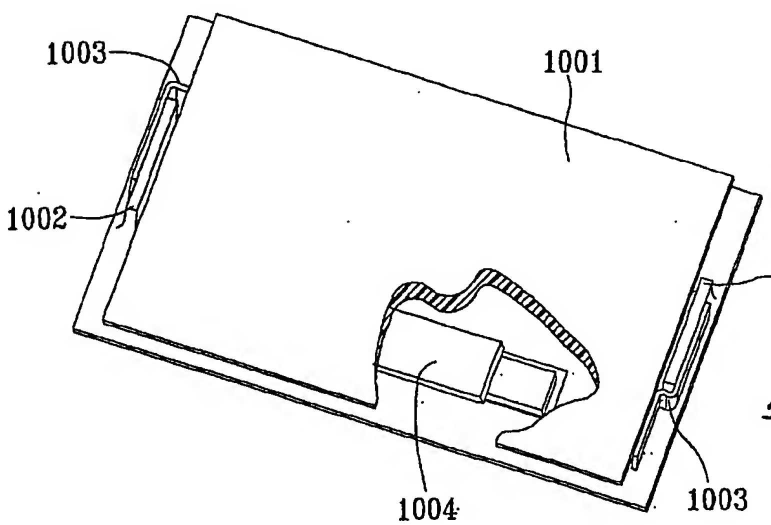

FIG. 10

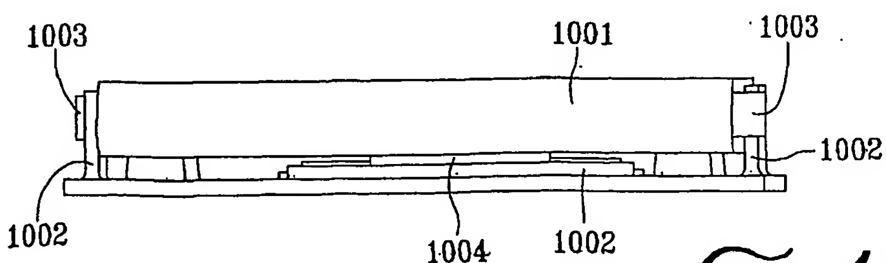

FIG. 11

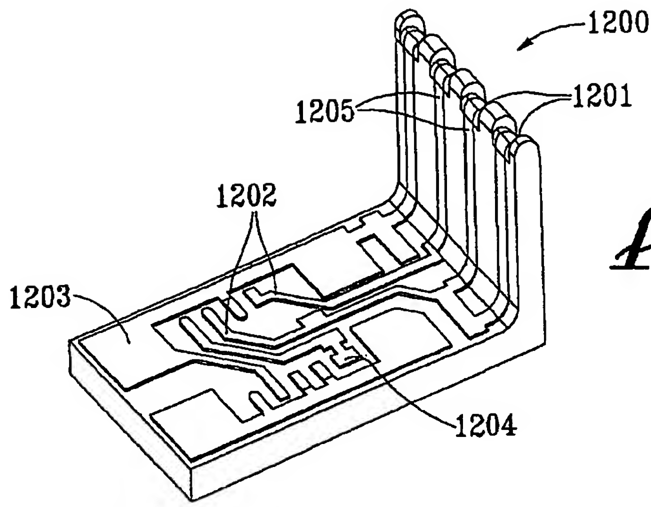

FIG. 12

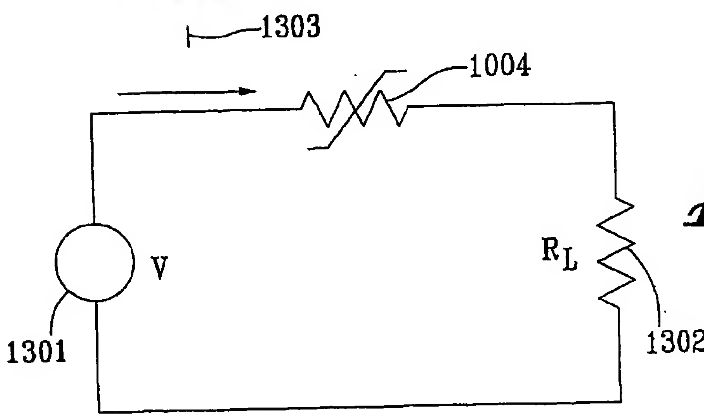

FIG. 13

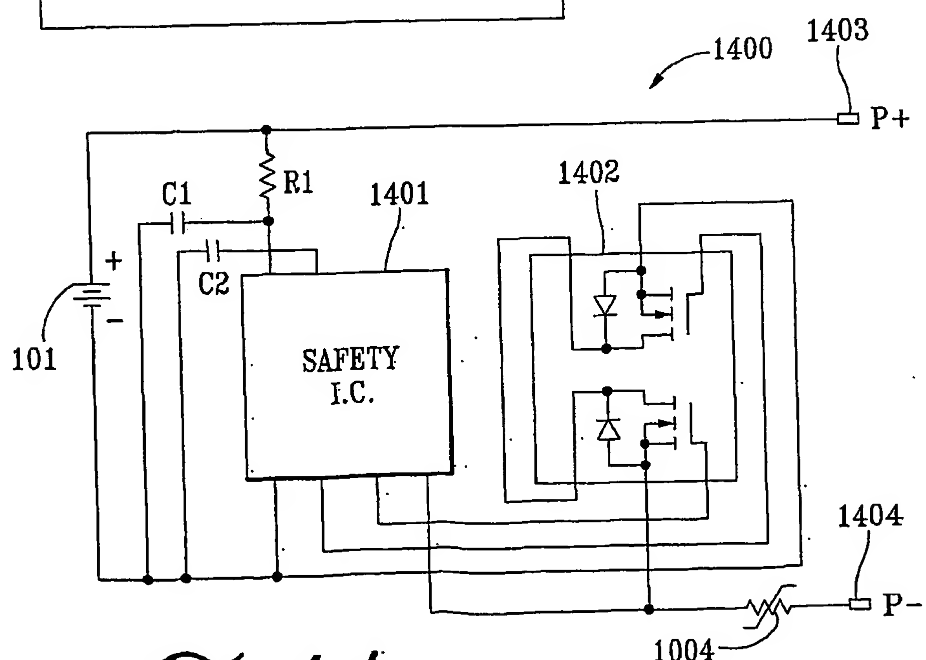

FIG. 14

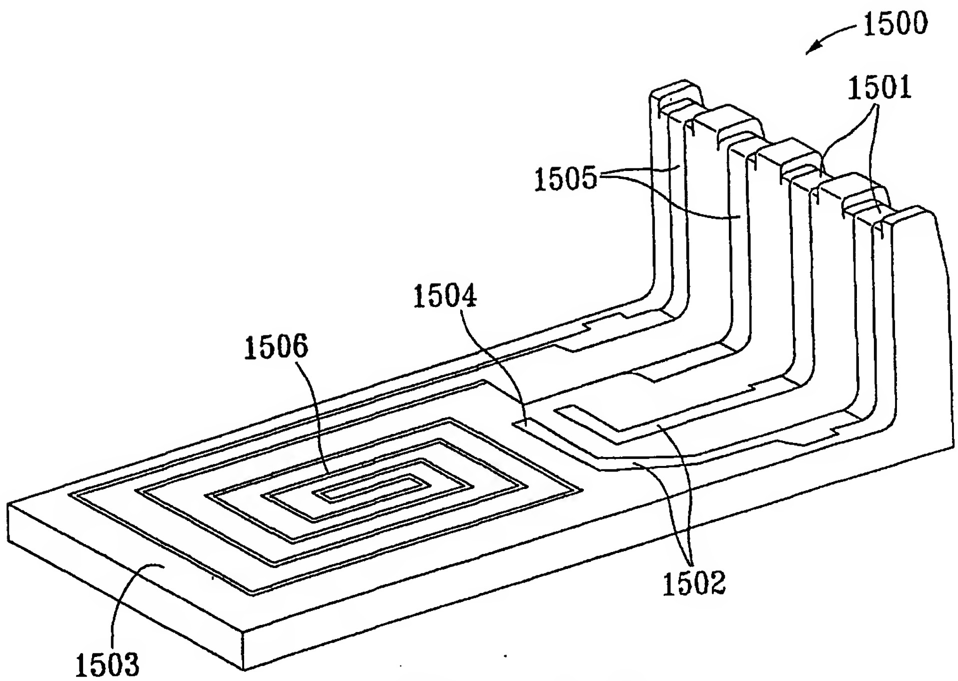

FIG. 15

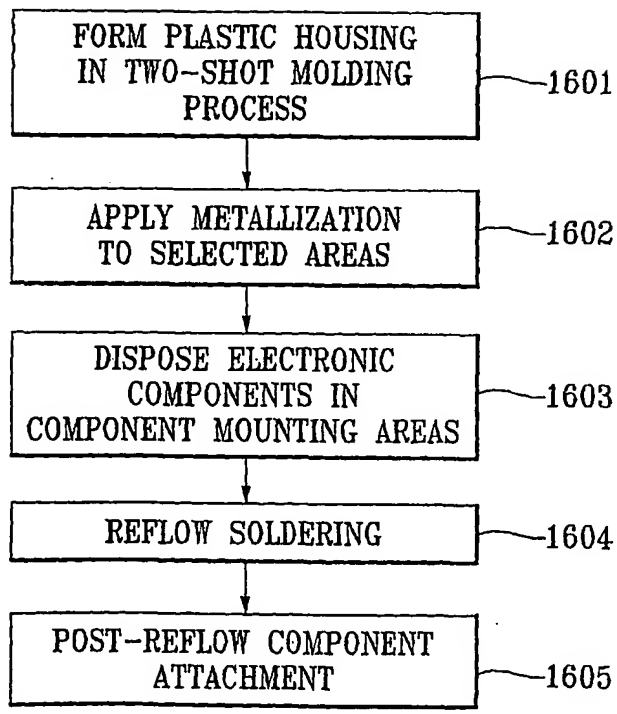
FORM PLASTIC HOUSING IN TWO-SHOT MOLDING PROCESS
1601
APPLY METALLIZATION TO SELECTED AREAS
1602
DISPOSE ELECTRONIC COMPONENTS IN COMPONENT MOUNTING AREAS
1603
REFLOW SOLDERING
1604
POST-REFLOW COMPONENT ATTACHMENT
1605

FIG. 16